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solplan review

the independent journal of energy conservation, building science & construction practice

Inside . . .

Silver Anniversary Issue

From The Editor . . .

This issue of Solplan Review represents 25 years of publication. We don't mean to take the simple journalistic route of doing a retrospective issue. However, in this age of fast technological change, electronic communication and instant gratification it is important to keep a broader perspective on what we are doing. It is good to look back from time to time to see where we've been and where we are headed.

Twenty-five years may seem like a long time – the term of a mortgage. But when we set out on this venture, the portable calculator was a recent innovation. There were no personal computers – one relied on typewriters. The office fax machine was still a rarity – you relied on mail and maybe couriers. Cell phones had just been launched – it was the old-fashioned phone, many with real dials that were used to compose a number. Research was done by going to the library and looking through books – the Internet did not exist. Wi-Fi and Internet cafés weren't even thought of, let alone e-mails on the job site. Photographs were taken on film and not on a digital disk.

As I look back on the 25 years Solplan Review has been published, I see how often we are bedazzled by technology, but forget the basic fundamentals. The technology itself becomes the product rather than the tool to deliver something with inherent value.

We seem to forget, or fail to pass on, lessons learned. Perhaps it is a human condition, but we have a hard time learning from past mistakes, especially in this industry. We seem to repeat them. Construction must be adapted to local conditions. If we forget this, it is at our peril. And if you consider recent problems in the construction industry, you will understand why. What works in a hot dry climate will not necessarily work in a sub-arctic or wet rainforest one. This is especially important to remember in the era of the Internet, which is the source of information for so many, yet seldom adequately deals with vital regional geographical context. .

In the past, change was slow, as was the tempo of construction. If an innovation was introduced, only a few buildings would incorporate it. If a new idea was tried, and the change turned out not to work, the consequences were not drastic. Today, construction is quick, and in large volumes. If a problem develops, a large number of buildings end up suffering the consequences of inappropriately used technology.

As I've scanned through past issues, the scope of the subjects we've covered amazes me. Twenty-five years ago when I started Solplan Review, no one else was doing anything comparable – reporting on investigations and translating research into language that practitioners in the field could put to use. Over the years we have seen a few publications come and go. However, it is marginal as a business venture, which is why there are few competitors. It has ended up being a combination of bad habit and a labour of love.

The R-2000 program was in its infancy when Solplan Review started. One of the program's cornerstones was builder training in an industry where traditionally there was little formal training. Knowledge was passed down from generation to generation, from father to son, through construction guilds, and on the job learning. Skills were passed on, but so were errors and misunderstandings about building performance and why things were done the way they were.

Training was crucial to the R-2000 program, as it was in introducing energy efficient construction techniques to a sceptical audience. Getting out the message that a house is a whole system required a carefully studied approach to changing construction practices. The R-2000 program was breaking new ground and was backed by many years of research. We already had the ability to do it right, but the message had to be conveyed to the job site.

The early years of the R-2000 program generated much enthusiasm among the residential industry, even if not all builders who took the training continued to build certified R-2000 homes. But while enthusiasm was generated, there was little follow-up. In a weak moment, I took on the effort to fill a gap and offer a vehicle for this communication.

Judging by the response I get, it seems to be filling a need. Despite the occasional rants from your editor!

Richard Kadulski,
Editor

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Solplan – What's in a Name?

As we put together this anniversary issue of Solplan Review, we thought it would be fun to review how this enterprise came to be. Back in the late 1970s, the era of the oil crisis, a lot of interest was generated in renewable energy applications. In homes, it was recognized that solar energy could and should be put to use for heating our homes.

As budding young idealistic architects, we noticed a lack of available home designs that incorporated solar energy applications into the design, so we set out to create a solar home plan book.

Solplan 1: Solar Houses for Canada was published in 1977. It contained 17 house plans, and was the first publication in Canada to focus on solar home design. The name "Solplan" was a combination of 'solar' and 'plan'.

The short book included commentary about solar energy principles, solar house design considerations, including plan layout, site selection as well as plans and a solar contribution worksheet. We pointed out that windows are thermal holes, and should be sensitively placed to optimize solar gains and minimize heat losses.

We advocated incorporating energy conserving construction techniques. At the time the standard construction practice for new houses was 2x4 framing, with R-12 insulation in the walls being considered to be a well-insulated wall. Typical windows, at least in coastal BC, were single-glazed, in non-thermally broken aluminium frames. We advocated use of double-glazing, and that consideration be given to triple-glazing. (At the time, vinyl frames and low-e were not yet readily available).

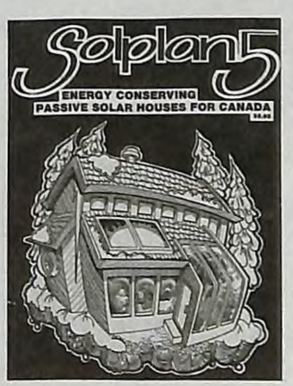
Our specs called for walls to be built with at least 2x6 framing at 24" o/c and ceilings R-30. We also encouraged that insulation be placed as far out in the wall/roof/floor as possible, and that a continuous air barrier and vapour barrier be installed. To avoid "stuffiness" in airtight construction, we advocated the installation of a proper ventilation system.

Today, to determine how homes might perform, or to optimize performance, we take it for granted we can use software such as HOT-2000 for calculating heat losses. However, in 1977 any analysis had to be done by manual calculations (the electronic calculator itself was a recent development), so one had to use rules of thumb or graphic chart tools. The personal computer did not appear until the late 1970s with the appearance of the Commodore PET introduced in 1977 and soon after the first Apple II. The first version of HOT-CAN (which eventually became HOT-2000) didn't show up until 1982, when the R-2000 program was initiated.

In *Solplan 1* we developed a solar contribution worksheet, which included climatic and solar data for major Canadian locations and a fill-in-the-blanks, step-by-step worksheet, to allow a user to calculate an estimate of annual solar contribution.

In the late 1970s, active solar was considered the way to go – you calculated how much heat was needed, then determined how much solar energy is available on the site. Since there is only so much solar energy available per unit area, if you needed a certain amount of energy, you needed to calculate how big the solar collection area had to be. Thus, the Solplan designs, much like early solar homes at the time, incorporated large areas of solar collectors.

Solplan 1: Solar Houses for Canada was followed up with a series of other books focusing on residential solar applications: *Solplan 2: Solar Energy for Existing Homes* (1978); *Solplan 3: Solar Greenhouses for Canada* (1979); *Solplan Almanac* (1980); *Solplan 5: Energy Conserving Passive Solar Houses for Canada* (1981).



Each of these included several worksheets to manually calculate solar heat gain contribution and related data.

When the R-2000 initiative was started in 1982, an extensive program of builder education was part of the exercise. It was recognized that you can't just insist on technical standards for energy efficiency without explaining to the industry what they are, and how to achieve them. The training was delivered by builders who themselves had been trained to deliver the workshops, so it generated a lot of enthusiasm. However, as the entire initiative was mainly funded by government, we noted the lack of a mechanism for continuing dialogue and information transfer. Being naïve entrepreneurs, we stepped in and decided we were going to do it , and building on the buzz we created with the Solplan books, set out to be that vehicle.

I can't pass up mention of my business partner and friend Terry Lyster, who's the genius behind the cartoon illustrations in Solplan Review. Bucky the beaver, as we affectionately call him (named after Buckminster Fuller) has graced out publications from the outset.

The hard-working beaver, the great engineer of the animal kingdom, mirrors the industriousness and inventiveness of Buckminster Fuller. Terry has been a great fan of Buckminster Fuller, and designed and built a number of geodesic domes in the 1970s. So when he put his creative skills to paper, it became an apt symbol.

Saskatchewan Conservation House

By 1980 it became clear that it was much more effective to build more energy efficient homes with low heat losses, taking advantage of passive solar gains, and only then look at active solar options. This was one of the key discoveries at the Saskatchewan Conservation House, the first high-profile, super-insulated and monitored solar demonstration home in North America, built in Regina in 1978.

The home's design and engineering team included Robert Besant, Oliver Drerup, Rob Dumont, David Eyre, and Harold Orr.

It was an airtight (0.8 air changes per hour at 50 pascals), energy efficient building envelope with such a small heating load that it did not require a regular heating system, even in the extremely cold Saskatchewan climate. The attic insulation was R-60 (blown cellulose), the walls R-44 (fiberglass), insulated floor R-30 (the house was built on piles without a basement), and the house had double-glazed windows, most on the south side, with insulating shutters on most of the windows.

Any house requires ventilation to control moisture, control carbon dioxide and body odour, and control volatile organic compound emissions – especially more airtight houses. A ventilation system was included in the Saskatchewan Conservation House. It featured the first plastic core air-to-air heat exchanger in Canada. It was a custom built unit that became the prototype for development of the heat recovery ventilators we have today.

Since the house was built as a solar demonstration home, it had a 190 sq.ft. vacuum tube solar collector system.

What was learned?

Features such as high insulation levels, good air tightness, and passive solar design all worked very well (and are inherently low maintenance.) On sunny days, the space heating was mostly covered by passive solar gain from the modest south windows, which were double-glazed with exterior insulating shutters.

The exterior movable insulating shutters had problems. In a high wind the shutters would rattle and shake the house, so the homeowner eventually removed the shutters.

The solar system was not commissioned when the house was completed. It was noted that there was no real need for the active solar system because of the home's extremely small heat loss. Based on the measured performance, the space-heating need of the house was 5.1 Gigajoules per year (4.8 million Btu) under normal occupancy conditions. A typical energy efficient home today would have an energy consumption in the range 50-60 GJ.

The vacuum tube solar panels used had a number of serious problems:

- Snow would collect on the outside of the vacuum tubes and not melt or slide off
- In a power outage on a sunny day, the glycol mix would boil and cause a vapour lock, effectively shutting down the collectors
- The pressure drop through the collectors was high, requiring a high wattage pump to circulate the anti-freeze solution
- The manufacturer stopped supporting the collectors, and then stopped making them.

Heat recovery on the ventilation air is very important in a low energy house, but maintenance of heat recovery ventilators exchangers must be done. Providing 30 L/s (60 cfm) of ventilation air when the outdoor air temperature is -35˚C (-31˚F) requires about 2 kilowatts of heat if no heat recovery is incorporated.

The overall lesson from the Saskatchewan Conservation House is that simple is better than complicated, passive is better than active, moving parts fail. In other words, it is important to keep it simple.

While the Saskatchewan Conservation house was built in 1978, it was not the only super-energy efficient house. In 1979, Gene Leger, a Massachusetts builder, built a similar super-insulated house in Pepperell, Mass.

Progressive builders and energy researchers throughout North America took notice. Within a few years, with a change in the energy picture, these projects soon lost their high profile. However, their standards were adjusted to be more palatable for the mainstream housing industry and emerged as the R-2000 standard.

William Shurcliff, a Massachusetts physicist who became the recorder of renewable energy and energy conservation ideas and projects, took note of these two super-insulated houses. In 1979 he suggested a new category for very low energy homes. He identified key features of such low energy homes:

Very high insulation levels – not just more, but carefully detailed and installed, with careful attention to airtight construction detailing including at difficult places – sills, headers, foundation walls, windows, electric outlet boxes, etc. The airtight construction also reduces the need for humidifiers in cold climates.

The architectural design was fairly simple.

There is little extra thermal mass. High-mass Trombe walls, and other thermal mass elements such as water-filled drums and thick concrete floors are considered an important part of passive solar house designs, but not always appropriate.

Well-insulated houses do not require extra-large south-facing windows. The passive solar heating is modest, almost incidental.

With very small heat loads, there is no need for a conventional furnace. Heat, when and if needed, can be taken from the domestic hot water system, or a small electrical heating element. There is little need for a conventional heat distribution system. Heat can be introduced into one spot and it will diffuse throughout the house.

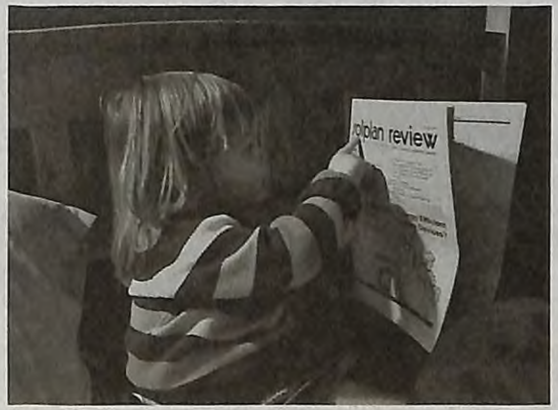
The cost of the extra insulation and extra care in construction are largely offset by the savings realized from not having huge areas of expensive windows, not having large elaborate insulating shutters for windows, and avoiding or downsizing the furnace or heating system.

The Saskatchewan Conservation house was the demonstration and testing ground for low energy construction concepts. These led to the R-2000 program in 1982, which showed builders how to apply these concepts to market houses. Although the R-2000 energy standard was not as high as for the Saskatchewan conservation house, it did set out a energy consumption performance target that provided an energy consumption at least 50% less than conventional houses at the time.

The Passivhaus

German physicist, Dr. Wolfgang Feist, took the ideas explored at the Saskatchewan Conservation house, the Leger house, and the R-2000 program and with a few modifications to the specifications, developed the Passivhaus standard for super-energy efficient homes in Europe.

The Passivhaus target criteria are a total heating and cooling demand of less than 15 kWh/m^2/yr (4,755 Btu/ft^2/yr). The airtightness limit is 0.6 ACH@50 Pa. How these levels are achieved are not spelled out prescriptively, rather it is a performance standard, not unlike the R-2000 standard.



One more Solplan Review fan... It is always wonderful to get feedback. More so to find out how the next generation is learning to read! This was sent to us by a faithful reader who caught his daughter reading Solplan Review.

Northern Building, a Quarter Century Ago

Wayne Wilkinson

Wayne Wilkinson lives in Whitehorse, where he has been a builder, consultant, and trainer for the past quarter-century. We asked him for some observations from the distant past – what changes he's noticed in his career. His observations point out how much, and how little, progress we've made in the intervening years.

Like most builders of my vintage our formative years in the trade were focused on production and structural integrity. At fifty cents a gallon, energy was not an issue. With a journeyman's wages around six or seven dollars an hour you could afford to turn the heat up and be comfortable. I found things somewhat different when I moved to the far north in 1974 where fuel was more than a dollar a gallon. The Arctic chill crept into the house. Snow and ice on the floor or frost on the walls was not uncommon.

Two winter experiences in the Keewatin district of the Northwest Territories changed my perspective profoundly and my focus as a builder for the rest of my career.

I became keenly aware, through my discomfort inside as the Arctic gale raged outside, that something was wrong with the way houses performed. I could not sit with my feet on the floor and there was a persistent snowdrift inching its way across the floor from the front door toward the back door.

On another occasion, in a different house, the building was just cold. Although the furnace was running full tilt, the temperature did not get above 50^0F. There was no snowdrift on the floor, but it was definitely colder on the windward side of the house. There was also no single malt scotch to aid in the musing. It was obvious that more insulation would help, as would weather-stripping around the door, but there seemed to be air coming from everywhere.

I began to think about lessons I was learning from Inuit and others that I traveled on the land with – about the importance of layering, keeping the wind out, and ventilation to control moisture buildup. In the Arctic, sweating can kill you. I began thinking how these simple survival skills could be put to use in making buildings more comfortable and cheaper to operate.

As luck would have it, I was asked in 1976 to provide two housing units for Northwest Territories Housing staff in each of three regional centres during the next building season. The project was to be a training program for local workers and it could demonstrate the benefits of air transport over sealift, stick-built technology (typical construction had been prefab stress skin panel construction), and improvements in comfort and energy efficiency.

To meet these requirements, the housing package would have to be flown in rather than barged, as the ice-free shipping season would mean that the packages would arrive too late – too late for a training project and too late for the extra time required for stick building. All too often, the day after the sealift arrives the housing packages are buried in the first snow of the season and winter begins.

In the interest of economy of construction and energy cost, it was decided that the buildings would be semi-detached. To protect the permafrost, the foundation would be an open crawlspace over a gravel pad with pads and wedges to support beams, and a floor system of standard wood framing construction, 2x6@16"oc with ½ inch plywood soffit, R-20 batts and ½ plywood on top. Another 2x6 "warm" floor was built on top of this after the exterior walls and roof were finished. The walls used were a revolutionary design for the time: 2x4 staggered stud exterior walls on 2x8 plates, with twice the insulation of conventional construction to eliminate most of the thermal bridging. The roof was standard truss design, without high heels, but efforts were made to stop infiltration of wind-blown snow, and R-20 batt insulation in the roof.

In addition to higher insulation levels in the walls, measures were taken to make the building more durable and afford some air-tightness. Before any interior partitions or the inner 'heating' floor were installed, a poly vapour barrier was placed over the ceiling and walls. All joints were to overlap by at least two framing members, and joints were to be made over framing members. Wall paneling was then installed over the poly to sandwich it with the wall sheathing and the ceiling was strapped with 1x4s. All joints in sheathing, poly and finishing materials had to be staggered so air could not pass directly through the joint. No electrical wiring was run within the exterior walls – the wiring was run in the warm floor and on the surface in a wire mold.

The warm floor had aluminum foil laid on the plywood sheathing and a 2x6 cavity framed over it. This cavity allowed for plumbing and the main plenum and heating ducts. Some heated air was also directed into the joist cavity to keep the floor warm. The bottom ends of each joist were cut at 45 degrees where the joist ended at the exterior wall to allow this air to circulate throughout the floor. A 5/8 plywood sub floor and underlay with AC tiles finished the floor.

From all accounts, the occupants found the houses to be comfortable and the NWTHC found them to be less costly to operate. Fine blown snow still infiltrated the attic despite our efforts. The newly trained workers found work on the regular construction jobs that started up after the sealift arrived and I moved to the Yukon, but it was a long time before my heart came to join me.

Yukon Housing

In the early 80s, Yukon Housing Corporation issued a proposal call for the design and construction of two government staff houses in Haines Junction, Yukon. The main criterion for the proposal call was based on the energy performance of these houses. To my knowledge, it was the first to use these parameters.

Each house was to be approximately 100 square metres in area, with three bedrooms and a basement. An energy budget of 50 watts per square metre was set as the maximum and the builder was required to submit a heat loss calculation to verify compliance. The builder was also required to follow the practices set out in the Vapour Barrier Handbook as produced by Rob Dumont of the Saskatchewan Research Council.

There were three bids for the job. One did not have a heat loss calculation, another did have a calculation, but failed to meet the energy target. The proposal from Turner Developments did survive scrutiny. It was within budget and met all requirements so a contract was issued and signed before the builder could change his mind.

Warm floor construction

There were a few innovations employed by the builder that no one had seen before. The 2x6 walls were strapped on the inside with 2x3s. A common practice today but, at the time, the builder had to mill his own 2x3s as they were not available from any supplier. The windows were triple-glazed, an uncommon upgrade for the day. There were "arctic entries" at both front and back doors and the house had a heat recovery ventilator. The HRV was one of the first models that CES produced (the forerunner of the vanEE brand, now part of Venmar). It was a far cry from today's HRVs, but in the early 1980s this was as high tech as it got.

Sometime after becoming an R-2000 inspector I had occasion to be in Haines Junction and had the opportunity to revisit the houses and do an air leakage test and run them through Hotcan (today HOT-2000) to see how they were performing. To my delight both houses tested to below 1.5 ach@50Pa and passed the energy budget for the R-2000 program.

Wayne's Closing Observations

The mid 1980s were the golden days of R-2000 in the north. We had lots of training and promotion going on. There was considerable R-2000 activity in both the NWT and Yukon. NRCan had their Conservation and Renewable Energy Offices in the field, with offices and staff in the Yukon and NWT to provide outreach.

Not much is happening with R-2000 up here anymore though there are still a few embers glowing. The CREO offices have closed. Yukon College no longer requires R-2000 training for carpentry apprentices, opting for the Alberta curriculum instead.

Yukon Housing Corporation (YHC) has their own GreenHome Program. YHC still offers training for builders, trades people and ecoEnergy energy evaluators and I do get the odd call from builders interested in the program. The training, product introduction and evaluation technology that was introduced during the program continues to have an ever expanding impact on the building industry. The technology developed by the program continues to be designed into buildings, adopted into code regulations and increasingly enforced by code officials.

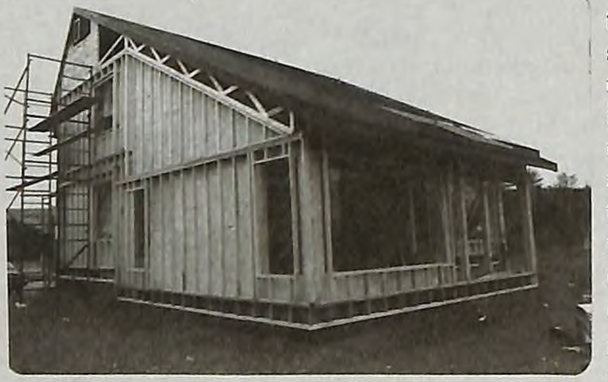
We've come a long way baby, but we've still got a long way to go. I hope that the revised R-2000 standard, scheduled for publication in 2012, will again lead the way

Housing For The 1980s New Brunswick Energy Efficient Housing Demonstration

Following on the energy crisis of the late 1970s, many were looking at changing the way we build homes.

The New Brunswick Housing Corporation (NBHC), the provincial housing agency, started a demonstration program dubbed "Housing for the '80s". The idea behind the program was to demonstrate low energy housing concepts that were originating on the Prairies at the time. It was thought incumbent on the provincial housing agency to help New Brunswick builders determine the applicability of new construction ideas and processes to the New Brunswick climate.

At the time, Bob Clarke was a designer with the NBHC, where he designed four double wall houses. The corporation then went on to build six of them in various regions of the province. Being a government agency, they were required to call public tenders for the construction of each house. As designer, Bob had to explain the intent of the project and the complete construction process to those builders intending to bid. It was his first experience in what has become nearly 30 years of involvement in consulting and industry training. He notes that all the builders who participated in that demonstration program went on to build many R-2000 homes in New Brunswick once that program got underway. Subsequent monitoring showed the process to be quite appropriate.

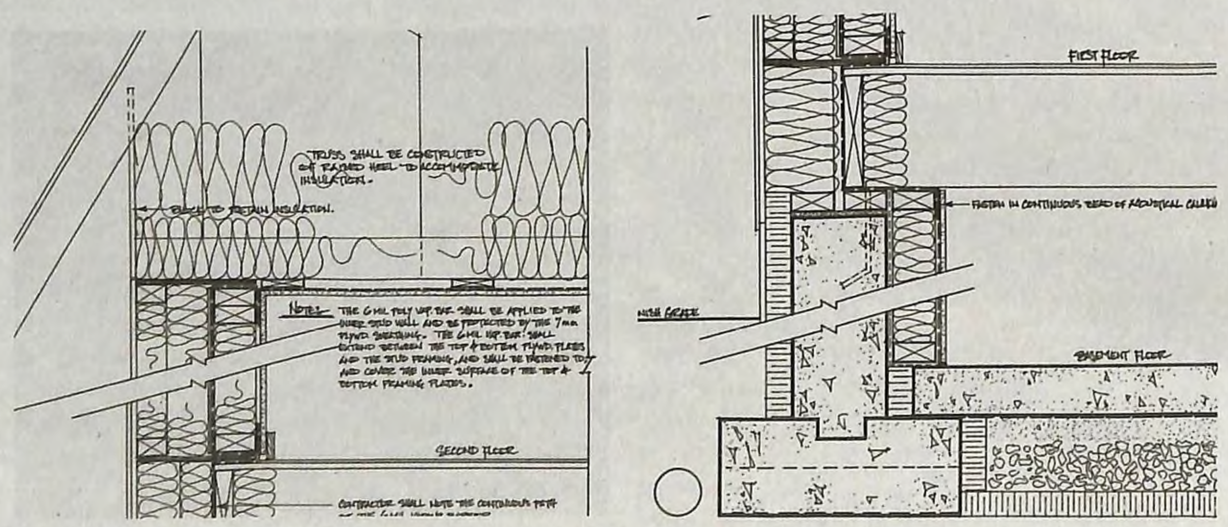


The house pictured here was built in Fredericton, Moncton and Saint John. The houses are still occupied, and function well. The exterior wall is a version of the 'double wall' concept with the inner wall being load-bearing and the outer frame set to accommodate insulation and the exterior.

The working drawings (completed by hand prior to computers) contained many large-scale details to assist builders with the new details and also to assist in the training process.

As I reviewed the details, I noted how remarkably current the details look. The insulation levels are close to those we see being used today in the Equilibrium and net zero energy homes.

Where have we been the last twenty-five years? What's been going on?



Construction details from the New Brunswick Housing Corporation demonstration houses working drawings.

Demystifying Green Home Programs

There is an increased desire everywhere these days to do the right thing – the 'green' thing. At the same time, there is a lot of green washing occurring. Claims are made with limited substantiation, and the confusion is being used to discredit some labels or to avoid taking action.

The increased interest in sustainable development has also resulted in a proliferation of labels – to the point that builders and their customers are getting confused. However, third party labelling programs help to alleviate some of the confusion in the market and provide credibility. For example, surveys indicate that government-backed support provides added credibility to a label.

When we look at what actions need to be taken to reduce the impact homes have on the environment, we find that there are common threads among the programs – energy efficiency, resource efficient materials, indoor air quality, water efficiency and low-impact landscaping. The specifics of what gets evaluated and how vary from program to program.

The biggest impact homes have on the environment over their life span is the energy they use for operation and maintenance. Over the life span of a house, a home will consume much greater quantities of energy than is used in the manufacture and construction of the home. That is why energy efficiency is one of the most important criterion that should be considered.

However, embodied energy, the energy used to manufacture the building materials, which includes accounting of raw material extraction, transport, manufacture and installation, often receives much more undeserved attention. Though embodied energy is a key attribute used by many designers when specifying products, products with a relatively high embodied energy such as foamed plastic insulation products can generate long term savings. Hence, products such as foamed plastic can result in net energy savings even when the embodied energy is taken into account, though this fact is sometimes not clearly stated or accounted for.

There are a number of new home initiatives that set out criteria to define what constitutes a "green" home. The highest profile programs are featured here.

R-2000™ Standard (R-2000)

Natural Resources Canada's R-2000 Standard is the foundation on which many energy efficiency and 'green' new home programs have been built. Planning for it was initiated in the late 1970s in response to the first energy crisis that was experienced as a result of an oil crisis. R-2000 was officially launched in 1982. From its inception, it was more than a mere energy efficiency program. The strength of the R-2000 initiative has been that, while it is largely focused on energy efficiency, it helped to define and formulate the "*house-as-a-system*" concept.

R-2000 has been the inspiration for many imitators around the world over the years, including a number of US housing programs. It is also the basis of the Super-E programs for exporting Canadian housing to Japan and the UK, and even the German Passive House standard that has been attracting interest recently.

The R-2000 Standard has been updated over the years so that today the technical criteria, while still largely energy focused, now also include indoor air quality features and other environmental features. However, the key benchmarks are a strict energy performance target and airtightness criteria with absolute pass/fail criteria.

To help ensure that newly constructed homes pass the R-2000 Standard, builders of R-2000 homes must attend and pass a two-day builder workshop. Then, as part of the certification process, each home must be evaluated by a licensed R-2000 plan evaluator to determine that each R-2000 home's energy target has been met for the location where it is built. In addition, each new house must be rigorously tested, evaluated, and inspected by R-2000 professionals at various stages throughout the construction process.

With improvements in construction standards and updated building code regulations, the current R-2000 equivalent energy target of EnerGuide 80 results in a home that is about 25% more energy efficient than current code built homes. In keeping with the R-2000 Standard's best-in-class status, it is reviewed and updated regularly. Currently, it is going through another review that should move the benchmark even closer to net-zero energy houses which have very low energy use. The proposals being reviewed may result in targets that are 50% more energy efficient than the current R-2000 Standard energy target.

R-2000

For information on the R-2000 Program, contact your local program office, or call
1-800-387-2000
www.R-2000.ca

EnerGuide Rating System (ERS)

The EnerGuide Rating System (ERS) is Natural Resources Canada's well-established rating system for the energy rating and labelling of products– mostly appliances – and homes. The ERS measures a home's energy performance, using a calculation based on standard operating assumptions to estimate how the house will use energy irrespective of the occupants' habits. Following procedures developed by Natural Resources Canada, a rating is determined by a certified energy advisor who works for a licensed EnerGuide service organization.

Since it is a rating system, there is no pass/fail level. ERS is used for both new and existing homes, and is based on a scale of 0 to100, with 0 being the least energy efficient. A house with a rating of 0 would essentially be an uninsulated, drafty house, while a very well insulated, net-zero energy house would rate 100. Depending on the region, today's new code-built homes in Canada rate in the low 70s with an average of 72.

For existing homes, the ERS is the basis for the ecoENERGY Retrofit - Homes program. For new homes, the ERS rating is often used by builders to determine energy efficiency upgrade packages that they can promote to their new home buying clients.

Although the ERS was not designed as a regulatory tool, and there is no intrinsic pass/fail within the system, a number of provinces and territories are introducing energy efficiency requirements in their building codes that establish energy targets. The ERS is often the measurement method of choice for compliance.

ENERGY STAR® for New Homes (available in Saskatchewan and Ontario only)

The ENERGY STAR brand is managed in Canada by Natural Resources Canada on behalf of the United States' Environmental Protection Agency. The ENERGY STAR for New Homes initiative promotes a cost-effective and flexible guideline for building energy efficient new homes, especially tract-built homes. It follows on the well-recognized ENERGY STAR brand for energy efficiency and applies it to new homes.

The ENERGY STAR for New Homes technical specifications, in essence, set out a prescriptive or performance path for construction of homes that exceed current code requirements by about 25%. This translates to an average rating of EnerGuide 80 which is the minimum rating that a current R-2000 house built to the baseline energy target would achieve.

ENERGY STAR for New Homes is delivered in the field for Natural Resources Canada by a network of regional service organizations in Ontario and Saskatchewan. It is anticipated that this program will spread to other regions in the near future. ENERGY STAR qualified homes are constructed by licensed builders, and are assessed by independent certified energy advisors who verify that the as-built homes meet the required technical specifications.

Built-Green™

Built Green™ is an industry driven voluntary program currently available in Alberta and British Columbia that promotes "green" building practices to reduce the impact that a home has on the environment. It has four certification levels, and the program includes mandatory builder training (based on NRCan's R-2000 builder workshop) and third-party testing, inspections and audits. An EnerGuide Rating System label is required on every house.

The primary objective of Built Green™ is to encourage homebuilders to use technologies, products and practices that will provide greater energy efficiency, reduce air pollution, provide healthier indoor air, reduce water usage, preserve natural resources, and improve building durability while reducing operation and maintenance costs and services.

The program checklist addresses qualitative items, while a minimum EnerGuide rating must be achieved to meet specific criteria for each of the four certification levels. For example, a gold certification requires a minimum EnerGuide rating of 77 and 100 checklist points, while platinum requires a minimum EnerGuide rating of 82 and 120 checklist points.

LEED Canada for Homes

LEED (**L**eadership in **E**nergy and **E**nvironmental **D**esign) Canada for Homes is a new initiative launched last year by the Canada Green Building Council. It is a rating system that promotes the design and construction of high-performance "green" homes that use less energy, water and natural resources, create less waste, have less impact on the environment and are healthier and more comfortable for the occupants.

The LEED Canada for Homes Rating System is based on the United States' LEED for Homes rating system that is a points-based checklist that lists intents and requirements for credits. LEED Canada for Homes service providers offer green home rating support services to builders – including training and inspections. On-site inspections are done prior to certification.

There are some limitations in the LEED Canada for Homes rating system. Although there is a requirement for energy efficiency, the minimum energy performance threshold is quite low. For example, the minimum energy requirement for LEED Canada Homes certification is to meet approximately an EnerGuide rating of 76, which is an energy performance level that in some parts of Canada may be less than minimum building code requirements.

There is also a Home Size Adjustment Factor that compensates for the effect of home size on resource consumption by adjusting the thresholds for each certification level (silver, gold, and platinum). For example, the base case "neutral" point for a three-bedroom house is one with 2200 square feet of total conditioned space (including basement). Hence, a larger three bedroom house would require more points to qualify for a given level than a smaller house. Although the minimum energy performance is not aggressive, LEED has more stringent minimum requirements for materials and site development including landscaping.

Another limitation of LEED Canada for Homes is that some checklist items are better suited to the US than Canada. For example, a strong focus on air-conditioning and landscaping is important in the southern US, but not as important in many areas of Canada, especially the more northerly Canadian regions.

EQuilibrium™ Sustainable Housing Demonstration Initiative

EQuilibrium is a Canada Mortgage and Housing Corporation (CMHC) and Natural Resources Canada joint effort. It is a national housing design and demonstration initiative to develop low-impact healthy housing for sustainable communities across the country. Fifteen homebuilding teams across Canada were selected to build EQuilibrium™ demonstration projects across Canada. Some of these projects are open for public tours and are monitored for performance. CMHC will make available the monitoring results.

The underlying principle was to build homes capable of producing an annual output of renewable energy that is equal to the total amount of its annual consumed/purchased energy from energy utilities. A home meeting these criteria could obtain an EnerGuide rating of 100. EQuilibrium homes are also referred to as net-zero energy homes, and similar net-zero demonstration homes are underway in many countries.

TEN COMMANDMENTS ACCORDING TO A BUILDER

The following tongue-in-cheek item was contributed by our accountant, who had just built his own house in 1992. Had he relied on the services of a professional contractor, he should have avoided many of the pitfalls. However, even the pro's get caught at it.

1. Nobody will notice after the drywall goes on. *(Translation- we goofed but if we slap enough drywall and plaster it will be covered up)*
2. I will be on site tomorrow. *(Translation - I took on too many jobs but that can't interfere with my golf game)*
3. It looked great on paper. *(Translation - I never thought that you would have to build this)*
4. That was not included in the price. *(Translation - I bid low to get the job but I need enough money for the Vegas vacation)*
5. Nobody (everybody) does it this way. *(Translation - I don't care what you want, this is the only way I know how to do it)*
6. It's the plumber's (electrician's) (carpenter's) job. *(Translation – Why should I worry if nobody else can do their work, my job is done)*
7. That's the size you ordered. *(Translation - Just because the guys at the plant can't read my writing does not mean that I am going to have it done right)*
8. This part was discontinued last Friday. *(Translation - The boss said to get rid of this white elephant or else)*
9. Everything but the money is extra. *(Translation - I gotta build up my retirement fund, doesn't everybody?)*
10. I know what I am doing. *(Translation - Haven't got a clue how to do this, but I'll wing it)*

Canadian Home Builders' Association

Technical Research Committee News

The Technical Research Committee (TRC) is the industry's forum for the exchange of information on research and development in the housing sector.
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Energy Star Programmable Thermostats

The Energy Star specifications for programmable thermostats have been suspended. Programmable thermostats have the potential for significant energy savings, but there have been many questions about how much savings are really achieved.

Programmable thermostats are not particularly user friendly, so few homeowners are able to program them properly, so that predicted energy savings are seldom achieved.

Minimum Mechanical Equipment Standards Upgrades

B.C. Energy Efficiency Act Standards

New energy efficiency regulations in BC that come in force September 1, 2010 will require the use of more efficient gas and propane-fired domestic water heaters. This will apply to storage-type water heaters with a storage capacity of 76 to 380 litres and an input of 75 000 Btu/h or less.

The required energy factor (EF) varies with the tank size. New minimum EF levels for several common sizes are presented in the table.

Gas Water Heater Efficiency

Rated Storage Capacity in litres (US gallons)	Minimum Energy Factor (EF)
114 L (30 US gal)	0.64
151 L (40 US gal)	0.62
181 L (48 US gal)	0.61
189 L (50 US gal)	0.61
246 L (65 US gal)	0.58
283 L (75 US gal)	0.56

The formula to determine the minimum is 0.70 – (0.0005×V), where V is the water heater's rated storage capacity in litres, as tested under the standard CAN/CSA-P.3-04: *Testing Method for Measuring Energy Consumption and Determining Efficiencies of Gas-Fired Storage Water Heaters.*

Electric storage tank type water heaters will have to have a rated standby loss (in watts) that is equal to or less than 25 + (0.20 x V) for those having a top inlet and a rated volume of 50 to 270 litres. For 50 to 270 litre water heaters with a bottom inlet, the requirement is identical to existing federal standards set by Natural Resources Canada, which require that the standby loss (in watts) must be equal to or less than: 40 + (0.20 x V).

Bottom inlet water heaters are those with a cold-water inlet that enters near the bottom of the storage tank of a water heater, but does not include a cold-water inlet that has a dip tube.

In addition, all electric water heaters must have a functioning heat trap installed at the inlet and outlet, or, in the case of bottom inlet water heaters, at the outlet. The heat trap may be a device or pipe configuration, either integrally connected or independently attached.

Electric Water Heater Efficiency

Rated Storage Capacity (litres)	Rated Storage Capacity (imp gal)	Max. Standby Loss (in watts): Top inlet water heaters	Max. Standby Loss (in watts): Bottom inlet water heaters
50	11	35	50
91	20	43	58
114	25.1	48	63
151	33.2	55	70
181	39.8	61	76
189	41.6	63	78
246	54.1	74	89

As well, all water heaters must be installed with R-4 (RSI 0.70) pipe insulation on the first 3.0 metres (9.8 ft) of exposed outlet piping (i.e. pipes not concealed in a wall, ceiling, or floor) down stream of the tank or heat trap and the first 3.0 m of exposed water inlet piping upstream of the tank or heat trap. If there is an independently attached heat trap, then the heat trap and the piping between the heat trap and tank must also be covered.

Manitoba Furnace and Boiler Efficiency Standards

Manitoba now requires minimum energy performance for furnaces and boilers. For new construction, federal energy efficiency regulations apply, which means that gas furnaces must meet a minimum 90% AFUE. However, for replacement furnaces in existing installations, the minimum efficiency has been set at 92% AFUE.

In new construction, boilers must meet a minimum 80% AFUE, and low pressure steam boilers must be at least 75% AFUE. Replacement boilers must be 82% AFUE, and low pressure steam boilers, 80% AFUE.

The Manitoba regulations are effective January 1, 2010.

Program facts about LEED Canada for Homes

Letters to the Editor

Rob Dumont's comments in the December issue of Solplan Review (No. 149) on the LEED Canada for Homes program elicited the following response from Chris Higgins, the LEED Canada for Homes Program Coordinator.

I would like to dispel some myths about the LEED Canada for Homes program. Four concerns were raised about the program: price, required documentation, the energy category prerequisite, and certification time.

Re Price: The Canada Green Building Council charges $215 for registration and $255 for certification (a little more for non-members and less for builders of more than 9 homes a year). These are the only fees the council charges for participating in LEED Canada for Homes.

All builders must also work with a Provider (an organization) and a Rater (a person). The Provider assists in the registration and certification process of projects and can also provide educational support on-site if needed. Another role of a Provider is to do quality control on their team of raters. Raters supply verification services (blower door testing, visual verification of installed features, etc) to LEED Canada for Homes registered projects.

Builders, developers and project teams that have worked with programs like R-2000 and EnerGuide will have experience working with a rater. Both the Provider and the Rater set their fees independently and competitively. Builders, developers and project teams have the right to choose any Provider from the eleven across Canada. Providers have no territories and compete with each other.

Each project is priced differently but, as an example, a builder building 9 homes targeting LEED Silver would likely pay a Provider a fee ranging from $200-400 per home depending on the level of assistance needed. The Rater fee is based on the hours the rater has to put in verifying performance. If the builder is not experienced in doing air-sealing details or has never built and modeled a home with EnerGuide, the cost is likely to be closer to the higher end.

The cost to a builder with experience in air-sealing details and who has built homes modeled under EnerGuide will be less. The range for a rater's fees might be from $1000-$1700 per home (again targeting silver with 9 homes together). Like most things, the first time has the most cost, as there is lots of learning. The second and third home cost less. Substantial discounts are available for volume builders.

Documentation: A common misunderstanding is to assume there are a lot of forms. However, there are only 3 forms required for submission to the CaGBC: a project checklist, a durability form and an accountability form.

In LEED-NC (the program for larger, Part 3 buildings) the rigor of the program is maintained through project team members signing forms to indicate installed features or performance. In LEED Canada for Homes, the rigor is maintained by a Rater that verifies the stated features, insulation or performance, using just 3 forms.

Energy performance requirement: Energy receives more points than any other category in LEED Canada for Homes. When considering energy it is important to understand that LEED Canada for Homes is a continuum standard. It provides rewards for exceeding the prerequisite.

As a national standard, LEED Canada for Homes aims to strike a balance. The minimum prerequisites (you get no points for meeting a prerequisite) should be achievable with a good effort everywhere. The standard gives credit for meeting the minimum, but no incentive to do better. Homes that excel are projects that greatly exceed the prerequisite and receive extra points.

Builders that use EnerGuide frequently have mentioned to me that there is a practical maximum somewhere around the low 90s so it is important to consider there is a very finite range. The average home certified to date has achieved just over 20 of 28 points in the performance path for energy.

Twenty points in LEED Canada for Homes can be achieved with an EnerGuide score of 89. Every home to date has exceeded the prerequisite level; none have just met it. It is my opinion that a program where the average home certified to date scores enough points to achieve EnerGuide 89 and every home certified to date exceeds the prerequisite is doing a good job at encouraging energy efficient homes. CaGBC will be reviewing the prerequisite level and consider increasing the minimum threshold in the near term.

Certification Time: LEED Canada for Homes has a streamlined certification process with an efficient review process. All LEED Canada for Homes projects to date have been certified in 3 weeks or less. Typically a project is registered during the design phase and, once the project is complete, it is submitted for certification. Within 3 weeks, certification is issued via e-mail and following that, a certificate is sent by mail. In a recent special case, in order to make a builder's grand opening, a project was certified in just 5 days.

I would encourage any potential builders with questions to follow up with a Provider via the LEED Canada for Homes website at *www.cagbc.org/leed/homes/*

The Green Home

Environmentally Friendly Housing

The concept of environmentally responsible homes has been talked about for quite some time now. In 1990 we put down our thoughts about what would define a "Green Home". It was the cover topic of the October-November 1990 issue (Solplan Review No. 35).

At about that time, Natural Resources Canada was preparing to challenge the housing industry to design and build super energy efficient homes. The initiative – known as the Advanced Houses program – led to ten demonstration homes being built across Canada in 1992-93.

The criteria for the Advanced Houses was an energy target at least 50% better than the R-2000 energy target, along with environmental, water conservation and resource efficiency considerations.

This article in Solplan Review was credited as being the inspiration for the team that designed and built the Waterloo Green Home in Waterloo, Ontario. Given the interest in sustainable construction today, we thought it timely to revisit the article.

The issue of the 1990s has already been established as the environment. The catch words are environment, recycle, reduction (of waste) and global warming. We've become aware of the mess we've been making of the planet, and unless we start to clean up our act, it's going to become terribly difficult for our survival as we may be starting irreversible changes on the planet.

The problem is so large it is difficult to come to grips with it. What can any one of us do about it? It may seem our individual efforts are too small to make a difference. But if each individual takes whatever action they can, it will have significant consequences.

We are already seeing more recycling. Blue box programs are flourishing faster than the ability of industry to actually be able to recycle waste material. But that is only the start.

Is the stress on the environment a fad? Something for big city people overwhelmed by smog and urban pollution to worry about? I think not, but at the same time the building industry should not feel threatened. The wise builder will use this public interest to develop products that meets, or at least go a long way in this direction. We have to remember we deal with a product that is going to be around for a long time. As we plan and build new buildings, we must consider the impact of the buildings over their life span. What is a small decision today may have very drastic consequences in the coming years.

Reducing the amount of waste generated during construction is only the start. We must look at construction with a new viewpoint. We must look at the kind of buildings we build, the materials, the operating costs. In the absence of another term, I'll call it the green home.

What are the features of an environmentally friendly green home?

It is energy independent.

Reducing energy consumption is important. This means construction with higher insulation levels and taking advantage of solar gains. It is possible to build homes in most parts of Canada that require no special heating systems. In other words they would be much more energy efficient than R-2000. (R-2000 standards should be the minimum for new homes).

It is healthy.

Products of construction should create a healthy environment. Materials should not off-gas or otherwise contribute to indoor air pollution. This may mean using more natural materials, fewer synthetics.

It must have a low environmental impact.

Materials used in construction should have little embodied energy (used in the manufacturing process) or not be the end result of toxic manufacturing processes.

There should be just enough space for comfort.

The most energy efficient mansion sprawling over thousands of square feet to house a couple with maybe one child is not efficient nor is it responsible. With proper design it is possible to provide comfortable, exciting and useable space. A compact design will use fewer materials and be even more affordable.

Mechanical equipment must be efficient.

Mechanical equipment is necessary to provide ventilation, a modest amount of space conditioning and hot water. The equipment should be the most efficient available.

Green Home Principles

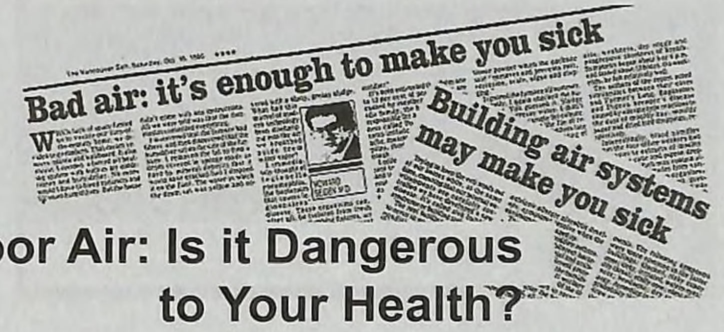
1. It is energy independent
2. It provides a healthy environment
3. It has a low environmental impact
4. It has just enough space for comfort
5. It uses the most efficient mechanical equipment
6. It has energy efficient appliances and lighting

Appliances and lighting must be energy efficient.

An important portion of energy consumption in buildings is the appliances and equipment used. Only the most efficient appliances should be used. A fridge that saves 120 kwh a month can save $50 or more per year for many years. So it makes economic sense, as well as environmental sense.

Is this all a dream? I don't think so. Many products are already available. We must simply consider how all of these go together. Builders that get involved now will be on the leading edge of environmentally friendly, healthy homes.

SOLPLAN REVIEW October-November 1990



Indoor Air: Is it Dangerous to Your Health?

Indoor air quality in new airtight buildings is a concern that has been with us as we've focused more effort at air sealing buildings, for better energy efficiency as well as enhanced durability.

Since the beginning of the R-2000 program, balanced ventilation has been a centrepiece of new home construction. Yet, despite it, questions and misunderstandings persist. This item, first published in 1986, could have been written today.

A recent nationally-syndicated medical column which appears in major Canadian newspapers discussed indoor air quality. The column, written by a doctor, underlines the ignorance that exists among the general population about the importance of a sound maintenance program for household mechanical equipment.

A leaky roof or tap is easy to see and fix, but improperly functioning equipment will not be recognized quickly. The problems often are invisible.

For the low energy builder, and the R-2000 Program, the challenge is to educate the public and overcome fears about tightly built houses. There are problems with new construction practices, but these have been, and continue to be, dealt with in a systematic fashion by the program.

Unfortunately, copycat houses built outside the regulation of the R-2000 Program, often at the insistence of owners who want to cut corners but don't quite understand the consequences of not following a carefully thought out building system in its entirety, are prime targets for problems. The most important R-2000 criteria is the requirement for balanced ventilation

The author of the column (talking about his new house) points out that:

"...the house didn't come with any instructions. All we were told was that the thermostat controlled everything. I discovered that the furnace had filters, and then discovered that the humidifier sat on the side

of the furnace. ... I removed the lid to find a... sponge made so hard by mineral deposits that it would have cracked had I dropped it . . . The water ... was yellow and covered a slimy, greasy sludge. What had this marvel of technology been discharging into the air we breathed?"

He goes on to talk about legionnaires disease and other respiratory diseases that have been identified with faulty air conditioning systems.

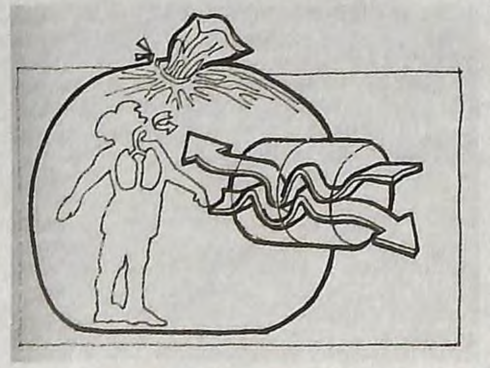
The implications are clear - faulty or poorly-maintained ventilation systems can create considerable health problems. There is considerable documented evidence to prove this.

Recently, a series of television stories have dealt with indoor air quality problems, mainly in office and commercial buildings - the so called 'sick building' syndrome. In most cases these are directly related to completely sealed buildings that rely on central heating/ventilating (HVAC) plants, where design or maintenance faults can lead to conditions that make it difficult to maintain good air quality.

The use of these central HVAC systems is relatively recent. It is only since the 1950s that widespread reliance has been made on mechanical systems to provide conditioned and liveable conditions inside buildings.

A major feature of the modern building with a central HVAC is that the building is completely sealed - windows don't open, so the only source of air is through the central system. If there is a problem with the HVAC system all occupants of the building will suffer.

Energy conservation activity spurred by the energy crisis of the 1970s has meant that systems now are being built to the limit - energy conservation has become a major design criterion. Systems are being designed to recycle maximum amounts of air, draw minimum amounts of fresh air and rely on filters and scrubbers to clean the air. All are new techniques and approaches.



However, these HVAC systems, like the choke on your car, can be throttled down too far. If this happens, the quality of the indoor air will not be adequate, and can lead to the various problems that are only now beginning to be recognized.

In recent years, people have begun to sense that something is wrong with these central systems as they exist in their work environments. This is why they become very concerned about talk of airtight houses.

As any low energy builder will appreciate, even the tightest house does not present the same situation because the house still has windows that open - and in each room at that! -- so that the resident can easily control his own environment. If it gets too stuffy, the window can be opened. As well, a properly built "tight" house will contain a ventilation system of some sort. Unfortunately, too few of the general public understands that. Ventilation systems for houses are too new an idea for most people.

In recent years, most conventional houses have been tightened up, so much so that the newly revised (1985) National Building Code has recognized the need for some form of mechanical ventilation. Up to now, balanced ventilation systems in traditional housing have been the exception rather than the norm. Continued R-2000 Program monitoring has proven that indoor air quality in a well built and designed house will be better than in conventional houses

R-2000 builders are already familiar (and hopefully thoroughly committed) to the need for balanced ventilation. For the new code changes to be successful, a considerable amount of builder and public education is still needed.

One interesting development we have heard about is a proposal by the Greater Victoria Homebuilders Association to make attending an R-2000 builder's workshop a condition of membership.

The Homeowner's Part

You can have the best designed ventilation system, but if it is not maintained properly, it will not do any good. As the doctor pointed out in his columns, some parts of the system may well provide the ideal conditions for breeding bacteria strong and nasty enough that breathing in the house could be hazardous to the health of the resident.

We know that many people are not familiar with or keen enough to maintain their house properly. Those of us in the building community may find this hard to understand. After all, it's not that hard to change a filter in the furnace, is it? But then because that is our livelihood, it is second nature to us. It seems so simple to tell a new homeowner to "be sure the filters are changed 2 or 3 times a year, and etc. . . " But you have to remember to do it!

But the homeowner, who may be a doctor, banker, salesman, teacher, stockbroker, or whatever, is often much more interested in other things. To him, an ordinary furnace or hot water tank is a technological marvel with strange knobs, screws, and pipes whose meaning and purpose is totally unknown (and he may be afraid of breaking the whole thing if he touches something the wrong way).

To do any regular maintenance, he has to remember that the equipment is there. If it is located in some dim part of the basement or crawl space, it will be forgotten (or not even discovered!) until something goes wrong.

(Personally, that's the way I deal with my car – I know where to put the gas and how to turn the key, but if something goes wrong, it's panicsville! Just what are all those things under the hood?)

Why place so much stress on ventilation systems and their upkeep?

We know that in recent years natural air leakage into houses has been reduced by improved construction techniques. Aside from issues of increased concentrations of pollutants in the house, there is a greater risk of carbon monoxide poisoning or asphyxiation to the occupants if combustion appliances do not have adequate provisions for combustion air.

A 1982 report estimated that about 10 people die in Canada each year and another 100 are hospitalized as a result of carbon monoxide poisoning due to incomplete combustion.

Balanced ventilation systems for occupancy are not meant to provide combustion air but if there were an inadequate supply of combustion air, the ventilation system will tend to reduce build up of toxic gases and ensure that the indoor air was constantly flushed clean.

So what is the solution to a healthy, sound design? There are a few points the builder should keep in mind.

Firstly, above all, the system design should follow the KISS principle: *keep it simple, stupid.*

Secondly, Murphy's Law should be accepted as a given. If something can go wrong, it will. A simple design, with a minimum of complex parts that can break down should be used. Always assume the worst possible scenario.

Thirdly, when selecting equipment, look for the best, most durable, easily serviceable equipment. If it is worthwhile to use a complex piece of equipment, look for its track record, warranty provisions, and availability of service and parts. (Why use a piece of equipment that can only be maintained by factory-trained service personnel in a location where such personnel are not available and if parts are needed, it will take two weeks to airlift them?)

If the equipment has filters that require periodic maintenance (and ideally that would be several times per year) don't place the equipment in a spot that only a 4-foot-tall Olympic gymnast can easily get at. Some HRVs have filters inside the main unit, which should be cleaned several times a year, yet we have seen units located in very shallow crawl spaces, hard to get at attic spaces, or hanging high in a workshop. Any guesses how often those filters will be changed? How many homeowners (assuming they've been told) will remember to change or clean the filters after two years of occupancy? We won't even think about the second purchaser.

And finally, a simple user's manual should be provided – something simple – even a one-page typewritten list of points to check and maintenance to perform. This could be attached next to the electrical panel (everyone sooner or later finds it).

Solplan Review No. 11 October-November 1986

Wood Frame Construction: Do We Build Them Like We Used To?

Building durability is an ongoing concern. Greater emphasis on energy efficiency and sustainability issues has generated concerns about whether all appropriate details are being followed. There is an awareness that poorly executed details can make a situation worse, and potentially lead to premature building failures. That was one of the key points that emerged in BC as the "leaky condo" crisis evolved.

Yet it has been know for some time that a house acts as a whole system. It's not possible to make changes in one area without considering its impact on the whole building. Since the early 1980s, the training developed to support the R-2000 program stressed the importance of the house-as-a-system.

In 1991, Joe Lstiburek contributed a piece to summarize what has changed in our construction practices in the past generation or so. He was emphasizing the need to keep in mind that a house-is-a-system or else we really may be creating problems as we move to improve building energy efficiency.

The same points are especially important today as we see the move toward net-zero energy housing. The article is as appropriate today as it was in June 1991.

We still hear the question, "Why can't we build houses the way we used to? We never had problems before." The answer is simple: people's expectations and the price of materials, labour and energy won't let us. Expensive construction costs, high energy bills and draughty houses just aren't acceptable to today's home buyers.

The problem is that we can't seem to build a new house today that will last. In Ontario, where detailed warranty statistics are kept, 2 out of every 10 basements get dug up within the first five years and are repaired. Mould and mildew in new US homes has become so commonplace that it is beginning to be accepted as the norm. Roof shingles are often replaced within 10 years. Paint seems to fall off siding every year. Has anyone ever seen a new home without drywall cracks? Interior moisture problems happen in all climatic zones. Once people move into these new homes they begin to get sick and, recently, with alarming frequency, they actually die from malfunctioning combustion space and water heaters.

But decaying homes and dead clients are not good for business!

When we renovate, rehabilitate, or upgrade we often work on buildings that have been around for 20, 30, 50, 75 years or more without substantial problems. Yet when we ''fix" them, or "improve" them, by adding insulation, installing new windows, replacing furnaces, changing siding or finishing basements we introduce them to the same problems found in today's new homes. It's as if they suddenly begin to behave like new homes. They now age at an accelerated rate and begin to deteriorate right before our eyes.

What's going on? We can't seem to build a new home that lasts, and we can't seem to fix an old one and have it continue to last. What has changed? What are we doing that is so different that is causing our new and rehabilitated housing stock to deteriorate?

We need to go back and understand what made our older housing stock so durable. How were these buildings built and why did we change the way we built them? What was the impact of these changes on durability?

Homes at the turn of the century in North America were not particularly comfortable. They were cold and draughty. Temperature stratification in rooms was common. It was not unusual to have a 10 or 20°C temperature difference between the floor and ceiling. It was possible to wake up on a winter morning in Saskatoon or Winnipeg and have your sheets frozen to the wall.

Insulation for Comfort

The first major change to construction practice was the introduction of thermal insulation to wall cavities and attic ceilings in the 1930s.

Insulation was added for comfort. People got tired of scraping ice indoors. Adding thermal insulation to the building envelope had two dramatic effects on the performance of the typical wood frame home. First, and of most importance to the builder, occupant comfort increased as heat loss through the building envelope was decreased and there was a more uniform heat distribution within the building. Second, as the insulation did its job keeping the heat inside the building, it reduced heat flow and air circulation through the cavities in the building envelopes. The sheathing, building paper and cladding now began to operate at a colder temperature. When these components became "wet" (usually as a result of exterior moisture, rain and dew) they stayed wet longer. The addition of insulation to the building cavities served to reduce the "drying potential" of the building envelope by reducing air circulation and heat flow. The more insulation and the more effective the insulation, the lower the envelope drying potential.

New Construction Trends Since The 1930s

We've been adding insulation to building envelopes since the 1930s, and presumably been reducing wall and building drying potential since then. So why didn't we see building disasters in the 1940s and 1950s? Why didn't Canadian and American cities come crashing down before our eyes as a result of rot and decay? Obviously other factors were at play.

One of these was the "leakiness" of older buildings. These older buildings were full of holes and they had a high air change rate. A high air change in a leaky house (in a heating climate) meant that interior moisture levels were kept extremely low as the cold replacement air contains very little moisture. The air change process serves to "flush" interior moisture out of a building enclosure. The leakier the building, the higher the air change.

However, the typical North American wood frame home started getting "tighter". A standard new home built today is four times tighter than the standard new home building fifty years ago. It wasn't entirely due to energy driven programs of the late 1970s that encouraged air sealing. Like most things in the building industry, the tightness happened as a by-product of other more important factors, such as cost and ease of construction.

In the 1940s "platform" framing became more common than "balloon" framing as it was a faster, less expensive way to frame a house. Gypsum wall board (drywall) began to replace plaster and lath as an interior surface finish during this period as it was faster, less labour intensive, and therefore less expensive to use. It does not take much insight to realize that a platform-framed house with gypsum wallboard as an interior surface finish is much "tighter" than a balloon-framed house with plaster and lath. The move to platform frame construction with gypsum wallboard took almost twenty years. (No one ever said change in the industry occurs quickly.) The result was a less expensive house that happened also to be tighter.

In the 1950s and early 1960s sheet goods such as plywood and asphalt impregnated fibreboard began to replace wood boards and plank decking on sub-floors, and as roof sheathing and wall sheathing. These sheet goods were faster and less expensive to install and soon dominated the market. The building envelope also became dramatically tighter.

The trend towards sheet goods was not due to a desire for a tighter building envelope, but because it was faster and less costly.

Energy Conservation and Draftproofing

The energy crisis of the mid 1970s became the first overt encouragement to build tighter building enclosures.

As the building envelope became tighter, the air change rate decreased. The interior moisture levels increased as the flushing action of high air change rates was reduced.

Another factor also began to influence envelope durability. During the late 1960s and early 1970s new cladding systems, such as hardboard aluminium and vinyl siding were introduced. These systems, while not being more airtight than the traditional wood cladding, were far less vapour permeable, so drying of the building enclosure to the exterior by diffusion was reduced.

The trend towards greater airtightness dates back to the 1940s and the lower permeability claddings dates back to the 1960s. Yet it is only in the early 1980s that we began to see ''building disasters" relating to moisture and durability. Why is it? The major reason is how homes are heated.

New Heating Systems

Until very recently, we used some form of combustion appliance coupled to an "active" chimney to heat our enclosures. We burned wood, coal, oil, and natural gas in furnaces that required air for combustion and generated combustion products. Additional air coupled to the active chimney was needed to exhaust these

products of combustion from the house. Such great quantities of air were required that as far as the house was concerned, these chimneys were nothing more than "chimney fans" or exhaust-only ventilation systems.

The operation of "active" chimneys increased the building air change rate and therefore reduced interior moisture levels. The exhaust depressurized the building to the point that infiltration happened over the majority of the outside envelope. It really did not matter very much how the building envelope was constructed as long as infiltration was occurring.

In the early 1970s there was a trend away from negative pressure houses with the introduction of electric heating. The moment "active" chimneys were removed" air change rates were reduced, and background moisture levels increased. More importantly, the neutral pressure planes began to lower. The typical building envelope went from a slight negative pressure to behaving like a hot air balloon that was too heavy to leave the ground. Cold, dry air would infiltrate the lower portions of the building, pick up heat and moisture, and exfiltrate through the upper portions of the building. The exfiltrating air was leaving at higher levels of moisture through fewer locations and these places were connected to building envelope cavities which were at a lower drying potential.

Electric heating is not the only culprit. New energy-efficient combustion appliances also consume less air. As far as the building envelope is concerned, these new efficient combustion appliances resemble electric heating.

Today's houses, newly built or renovated, with high levels of insulation and low drying potentials, low air change rates and low neutral pressure planes are major candidates to long-term durability problems.

Unfortunately, durability of the building enclosure is not the only concern. As the building enclosures become tighter, combustion appliances and their "aerodynamically coupled" (to the enclosure) chimneys begin to compete with other air-consuming devices in the buildings for air. The "passive" chimneys don't always "win" the competition for available air, and spillage and backdrafting of products of combustion happens. The impact on health and safety is obvious.

As building enclosures become tighter and air change is reduced, not only do background moisture levels rise, but indoor pollutant levels also rise. It has become clear that the trend towards "tight" construction cannot continue without some concession to ''controlled ventilation".

The House Is A System

It is sad and ironic that in North America we are actually "institutionalizing" the process of problem creation. Government programs promote higher levels of insulation, and more recently, tighter building enclosures in order to save energy, without appreciating the impacts on durability of the structure and the health and safety of the occupants. Energy conservation is important, but health and safety of the occupants and the durability of the enclosure is more important.

This is why recent code changes were made to mandate mechanical ventilation. It is inevitable that today's homes will continue to have high levels of insulation, low air change rates and lower neutral pressure planes. It is critical that building envelope design and construction reflect this new reality and compensate for it. It is possible and desirable to build building enclosures with high levels of insulation and also high drying potentials. It is possible and desirable to build "tight" building enclosures with combustion appliances that do not interact with the occupants and other air-consuming devices. It is possible and desirable to maintain the air quality (health and safety of the occupants) in a controlled manner within these "tight" building enclosures.

This emphasizes the importance of keeping in mind that a house acts as a whole system: you can't make changes in one area without considering the impact on the whole.

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Energy Answers

Rob Dumont

Are global temperatures still rising? I read on the Energy Probe web site that "About 10 years ago, temperatures stopped climbing. They plateaued and then started falling."

Energy Probe should do some fact checking. I went back to the original source data to have a look at temperatures over the last 120 years. The following data, from the U.S. National Aeronautics and Space Administration (NASA) Web Site, shows global temperatures from 1880 to the present.

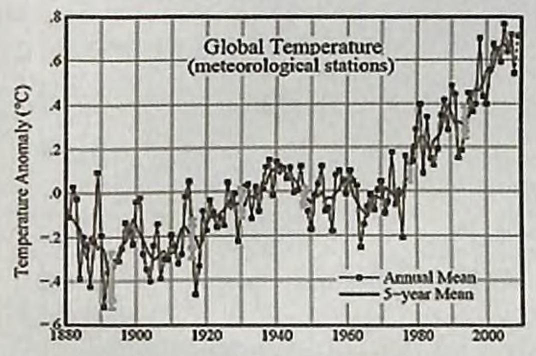


Figure 1. Global temperature change (1880 to the present)

The squares on the graph show the annual mean temperature from 1880 to the present, and the smooth line shows the running 5-year mean temperature. As can be seen, global temperatures have been rising, particularly since about 1963.

Year to year, there are fluctuations in temperature, and these fluctuations are caused by a number of factors including ocean temperature fluctuations (El Nino and La Nina, for example), volcanic eruptions, dust levels from fires and winds, solar radiation variations, variations in ocean currents, etc.

If you look on the graph for 1998, it was a significantly warmer year than either 1997 or 1999. Some climate change deniers have seized on that one warmer year in 1998, and made the claim that the earth is now cooling.

There is an old saying that "One swallow does not a summer make." If you look carefully over the annual data on the graph, there are relatively large fluctuations from year to year, and it is not legitimate to use one year as a reference point. The five-year averages are much more legitimate to use in any comparisons. Based on the five-year averages, the earth is definitely <u>not</u> cooling.

What is the primary driver of increased global temperature?

The largest factor driving increased global temperature is rising carbon dioxide emissions.

The graph in Figure 2 shows the values of carbon dioxide in the atmosphere from 1960 to the present. Before the industrial revolution, the carbon dioxide levels in the atmosphere were about 280 parts per million by volume. As can be seen from the graph, the current level is about 385 ppm.

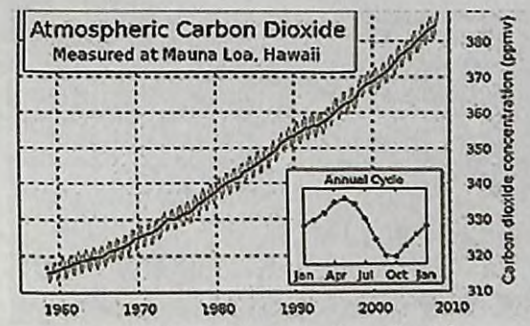


Figure 2. Atmospheric carbon dioxide levels (1960-present)

Why would Energy Probe make such a statement?

I had a look at the principles of the organization, and here is the lead-off principle on their web site: "1. We work for environmental sustainability by promoting property rights (private or communal)…"

On this planet there is one sky. Property rights, private or communal, will never protect the global commons of the atmosphere. We are all downwind of our energy use. It certainly is not helpful for a Canadian organization such as Energy Probe to jump on board the climate change deniers train. This is very sad state for an organization that was spun off from Pollution Probe.

The late U.S. Senator Daniel Moynihan once said: "People are entitled to their own opinions; they are not entitled to their own facts." Energy Probe should get its facts straight.

Anyone who does not believe that global warming is happening probably believes that Elvis is alive, the earth is really flat, and Obama was not born in Hawaii.

NRC-CNRC

Effect of wall energy retrofits on drying capability

By Dr. Wahid Maref

In an article in Solplan in 2007, NRC-IRC reported on its new *Ventilation and Wall Research House.* This current article reports on research recently completed using the wall facility part of the house. The research examined the effect of two energy retrofit strategies on wall wetting and drying.

Test walls

Three wall specimens were installed side-by-side into test bays. Wall 1 was the reference wall with nominal batt RSI of 3.5 (R20). Wall 2 was upgraded by installing 50 mm XPS rigid foam insulation to provide a wall nominal RSI of 5.25 (R30). Wall 3 was upgraded by RSI 1.76 (R10) by adding 63.5 mm semi-rigid mineral insulation boards installed horizontally (Table 1).

Test Conditions

The wall specimens were exposed to natural weather conditions on the exterior side, while temperature, relative humidity, and pressure conditions on the interior side were varied.

The two retrofitted specimens (Walls 2 and 3) were challenged with high indoor relative humidity and air pressure levels while construction deficiencies providing a path for air leakage were introduced. The reference test wall (Wall 1) was constructed with no controlled air leakage path.

Data were collected to examine the hygrothermal response of the test specimens at critical locations within the test assembly over the Fall 2007 and Winter and Spring 2008. The performance of the two retrofitted test specimens was compared to that of the reference wall.

Results

The results showed that adding some thermal insulation to the exterior of an insulated stud cavity can contribute to reducing the duration of the potential for interstitial condensation, but condensation can still take place during the coldest period of winter in a climate such as Ottawa.

The study showed that necessary conditions for condensation are: cold exterior temperatures resulting in an interstitial surface temperature below the dew point of room air, an air leakage path through the wall assemblies, air pressure indoor higher than outdoor (air exfiltration drive) and indoor moisture load.

It was found that the air and vapour permeance properties of the insulation material positioned on the exterior of the stud cavity had some effect on the moisture transport and distribution across the wall assemblies. The XPS foam exhibited lower vapour and air permeance than the mineral fibre insulation and this difference in properties can explain the lower rate of moisture transmission through the XPS foam. Higher vapour pressure or absolute humidity differences were observed across layers with low air and vapour permeance. For "reversed" moisture flow (summer conditions), the wall assembly with XPS exterior insulating sheathing exhibited a lower vapour permeance than the one with semi-rigid mineral fibre, reducing the rate of migration of exterior moisture inward towards the stud cavity materials.

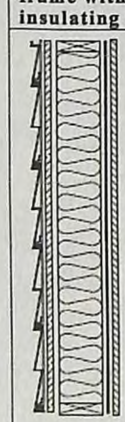
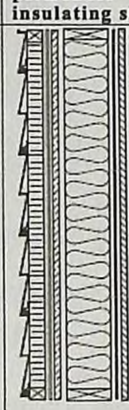
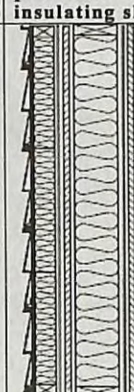
Both wall assemblies with external thermal insulation experienced short-term wintertime condensation wetting in the stud cavity when air exfiltration was present during sufficiently cold weather conditions; however, both wall assemblies dried out without any apparent stains or damage to the stud cavity materials.

The two assemblies with exterior insulation were less prone to interstitial condensation than similar walls without such exterior thermal insulation. The study showed that the addition of an exterior insulating sheathing raised the temperature of the stud cavity materials and could maintain them above the dew point of interior air, thus reducing the likelihood and duration of interstitial condensation, within limits. When the outdoor climate got very cold, the benefit of the insulating sheathings on reducing the condensation potential was reduced.

Both retrofitted wall systems managed moisture appropriately but through different mechanisms in winter and summer, thereby showing the benefits of retrofitting wall systems with these exterior insulations.

For more information about the research, the wall test facility and partnership opportunities, visit the website
http://irc.nrc-cnrc.gc.ca/bes/facilities/fieldex_e.html
or contact Dr. Wahid Maref
Wahid.maref@nrc-cnrc.gc.ca

Table 1 Description of base wall and test walls

Wall 1 (reference wall) 38 x140 mm insulated wood-frame with no exterior insulating sheathing		Wall 2 Lower air and vapour permeance insulating sheathing		Wall 3 Higher air and vapour permeance insulating sheathing	
	• Vinyl siding • Sheathing membrane (spun-bonded olefin) • 11-mm OSB wood-sheathing (with a 6-mm horizontal gap at mid-height) • 38 x140 mm (2X6) nominal stud cavity with RSI3,5 (R20) glass fibre insulation batts • Plastic air/vapour barrier • Painted drywall		• Vinyl siding • 50-mm XPS rigid foam insulation, 609-mm wide sections installed horizontally, square edge • Sheathing membrane (spun bonded olefin) • 11-mm OSB wood-sheathing (with a 6-mm horizontal gap at mid-height) • 38 x140 mm (2X6) nominal stud cavity with RSI3,5 (R20) glass fibre insulation batts • Plastic air/vapour barrier • Painted drywall		• Vinyl siding • Sheathing membrane (spun-bonded olefin) • 19 x 38 mm (¾ x 1½ in.) vertical strapping @ 400 mm) o.c. mounted on blocks • 63.5-mm semi-rigid mineral fibre insulation boards installed horizontally • Sheathing membrane (spun-bonded olefin) • 11-mm OSB wood-sheathing (with a 6-mm horizontal gap at mid-height) • 38 x140 mm (2X6) nominal stud cavity with RSI3,5 glass fibre insulation batts • Plastic air/vapour barrier • Painted drywall

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What is The Evidence for Climate Change?

Recently released data show that the 2000-2009 decade was the warmest on record, easily surpassing the previous hottest decade — the 1990s. In 2009, global surface temperatures were 1.01 degree above average, which tied the year for the fifth warmest year on record, according the US National Climatic Data Center.

Temperatures between 2000-2009 are about 0.96 degree above normal, which shattered the 1990s record value of 0.65 degree above normal. The warmest year on record was 2005 at 1.11 degrees above normal.

Record-breaking weather events have been observed around the world. While no single event has a direct relationship, the severity and number of wild weather incidents is an indication of a changing climate.